

**TAXONOMIC AND BEHAVIORAL STUDIES OF A NEW DANCING
BELTHECA BUSCK (LEPIDOPTERA: GELECHIIDAE) FROM COSTA RICA**

AKITO Y. KAWAHARA AND DAVID ADAMSKI

(AYK) Maryland Center for Systematic Entomology, University of Maryland, 4112 Plant Sciences Building, College Park, MD 20742-4454, U.S.A. (e-mail: kawahara@umd.edu); (DA) Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20013-7012, U.S.A. (e-mail: dadamski@sel.barc.usda.gov)

Abstract.—*Beltheca oni*, new species, is described from the Atlantic lowlands of Costa Rica. The adult female is similar to that of *B. picolella* Busck, but the former lacks a signum. The male can be distinguished from that of *Beltheca phosphoropa* (Meyrick) by its longer vinculum and larger aedeagus. Adults of both sexes “dance” on leaves of different plants by anchoring one of their forelegs to a substrate and rotating around this pivot point. The anchored leg shifts slightly when the moth dances in large circles, moves to another region of the leaf, or changes the direction of rotation. There is no preference for rotating clockwise or counterclockwise. Dancing occurs all over the adaxial leaf surface, but it can be localized. An adult was observed dancing around a water droplet and drinking from it. We hypothesize that dancing is a courtship behavior or a predator avoidance tactic. A photograph of the adult and illustrations of the head, wing venation, and genitalia of both sexes are included along with a diagram of a dancing path.

Key Words: Anacampsinae, behavior, *Beltheca*, *Commatica*, courtship dance, microlepidoptera, morphology, predator avoidance, taxonomy

The genus *Beltheca* Busck is represented by two Neotropical species, *B. picolella* Busck, and *B. phosphoropa* (Meyrick). Busck (1914) proposed *Beltheca* based on the type species, *B. picolella*, which he described from Cabima, Panama. Clarke (1969) synonymized *Anterethista heteractis* (Meyrick) with *B. picolella* and transferred *Anterethista phosphoropa* (Meyrick) to *Beltheca*. *Beltheca phosphoropa* is known from Jurimaguas, Peru, and Pará, Brazil (Meyrick 1922). Nothing is known about dancing or the life history of either species.

“Dancing” in microlepidoptera has been defined as “running in tight circles with a crab like sideways gait” (Robinson 1988: 73). Dancing has not been reported in *Bel-*

theca, but it has been documented in three other gelechiid genera. In the United States, Clemens (1860) reported *Strobisia* dancing on the surface of shaded leaves, and Forbes (1923) observed dancing *Anacampsis agri-moniella* (Clemens) and *A. levipedella* (Clemens). Aiello and Becker (2004) reported *Commatica falcateella* (Walker) and *Commatica cryptina* (Walsingham) dancing in Mexico, Costa Rica, and Panama.

There have been many reports of dancing in microlepidoptera, but few studies describe the behavior in detail. Most detailed studies focus on the jerky display behavior of choreutids (e.g., Rota 2003, Aiello and Becker 2004), which is different from the rotating dance of other microlepidopteran

families (e.g., Gelechiidae, Cosmopterigidae, Momphidae, and Tineidae). Despite the numerous reports of dancing in Gelechioidea (e.g., Forbes 1923, Plant 1980, Robinson 1988, Aiello and Becker 2004), there has never been a detailed description of dancing for any species in the superfamily. The purpose of our study is to describe the morphology and dancing behavior of a new species of *Belthea* from Costa Rica, and to hypothesize the ecological significance of its dance.

MATERIALS AND METHODS

Adults of *Belthea oni* were collected on plants growing along the edge of a pasture at the El Ceibo Research Station (500 m), west side of Rio Peje, Heredia, Costa Rica, in February 2003 and March 2004. All specimens were collected using a killing jar containing potassium cyanide after observations of dancing were recorded. Adult behavior was documented, and video footage of 24 adults was taken using a Nikon Coolpix 4500 digital camera. A number was assigned to each specimen corresponding to the appropriate video file. Each video was played frame-by-frame and the dancing path sketched. QuickTime® video files are in the possession of the primary author.

The illustration of the head was made with a camera lucida attached to a WILD M5 microscope, and genitalia drawings were made with a Jena Pictoval Microslide Projector. Wing and genital dissections were permanently mounted on glass microscope slides and deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA (USNM), along with the holotype and 12 paratypes. Twenty additional paratypes are deposited in the Instituto Nacional de Biodiversidad (INBio) collection in Santo Domingo de Heredia, Costa Rica. Nomenclature for genitalia follows Klots (1970), and terminology for wing venation follows Comstock (1918). Wing length is defined by the distance from the wing base to the apical margin.

TAXONOMY

Belthea oni Kawahara and Adamski, new species (Figs. 1–10)

Diagnosis.—The female of *Belthea oni* is similar to that of *B. picolella* but lacks a signum. The male of *B. oni* has a longer vinculum and larger aedeagus than that of *B. phosphoropa*. The male of *B. picolella* and female of *B. phosphoropa* are unknown, and therefore could not be compared with *B. oni*.

Description.—Adult (Fig. 1). *Head* (Fig. 2): Scales on head teardrop shaped, dark brown with bronze iridescence. Antenna filiform, 2.1–2.2 mm in length, with 58–60 flagellomeres ($n = 4$ antennae). Labial palpus upcurved, 2.2–2.3 mm in length ($n = 14$), approximately two times horizontal length of head; labial palpus with second segment dorsoventrally wider than third, with long raised scales on dorsal surface. Proboscis approximately two-thirds length of body. *Thorax*: 1.3 mm in length, dorsal surface covered with small bronze oval scales, ventral and lateral surfaces covered with longer scales. Forewing (Figs. 1, 3): Elliptic, 3.5–4.6 mm in length ($n = 25$), dark bronze, ventral surface similar but paler. Forewing with short, narrow scales along swollen base of subcosta and radius, female with more scales at base of subcosta than male. R_5 absent, M_1 closer to R_4 than to M_2 in both sexes. Hindwing (Figs. 1, 4): Dark brown, R_s straight to pointed apex, M_2 arising from approximately midpoint of distal margin of discal cell, slightly arched broadly toward M_1 . Frenulum approximately one third length of $Sc + R_1$; male with one acanthus, female with two acanthi. *Abdomen*: Dark brown, approximately 2.2 mm in length. Male genitalia (Figs. 5, 6): Uncus elongate, broadly curved apically, with numerous peglike setae on ventral surface; gnathos elongate, enlarged basally; tegumen with several setae along ventral margin; valva broadly curved from base, distal half of inner surface setose, transtilla C-



Fig. 1. *Belthea oni*, holotype male. Scale = 1.0 mm.



Fig. 2. Head of *Belthea oni*, lateral view of male. Scale = 0.1 mm.

shaped; vinculum elongate and sharply pointed medioventrally; aedeagus ovate and apically hooked. Female genitalia (Figs. 7, 8): Papilla analis setose, apophysis posterior extending nearly to anterior margin of eighth tergum, apophysis anterior very short. Lamella antevaginalis semicircular, medially notched; ductus bursae long and narrow; corpus bursae oviform with an accessory lobe at posterior end, lobe pointed and sclerotized at base of ductus seminalis.

Type material.—Holotype: ♂, COSTA RICA: Heredia Province: 11 km southeast of La Virgen, west side of Rio Peje, El Ceibo Station. 21 February 2003, A. Y. Kawahara. The specimen bears the following labels: printed white label: COSTA RICA: Heredia Province: 11 km Southeast of La Virgen, El Ceibo Station, 10°20'N 84°04'W, 450–500 m, INBio-OET-ALAS transect, 21-II-2003; Akito Y. Kawahara leg.; printed red label: HOLOTYPE, *Belthea oni* Kawahara and Adamski 2006 (USNM).

Paratypes (30 ♂, 2 ♀): Same data as for

holotype, 20 male paratypes deposited in INBio, each INBio paratype with a unique Project ALAS white label with INBIO barcode numbers: 003226769 to 003226775, 00322686 to 003226828. Twelve paratypes (10 ♂, 2 ♀) deposited in USNM. Slide mounts were made from dissections of some USNM paratype specimens. Each dissected specimen and slide has a numbered label: male genitalia (USNM #82629, #82630, #82634, #82635), female genitalia (USNM #82631, #82632), male wing venation (USNM #82628), and female wing venation (USNM #83158).

Other specimens examined.—2 ♂: 11 km southeast of La Virgen, west side of Rio Peje, El Ceibo Station. 21 March 2004, A. Y. Kawahara (USNM). 5 ♂, 1 ♀: La Selva Biological Station. 10°26'N 84°01'W, 18-IV-2002; “dancing” 15:00–16:00 h, successional plots, D. & M. Davis (USNM), genitalia slides: #82634 (1 ♂) and #82635 (1 ♀).

Other types examined.—*Belthea phosphoropa* (Meyrick), lectotype (Clarke 1969: 353): ♂, Jurimaguas, Peru, Parish, 20-III (BMNH). *Belthea picolella* Busck, lectotype of *A. heteractis* (Clarke 1969: 353): ♀, Bartica, British Guiana, Parish, 13-II (BMNH); syntypes: 2 ♀, Cabima, Panama (USNM).

Distribution.—Recorded from the Atlantic lowlands of Costa Rica, specifically La Selva Biological Station and El Ceibo Research Station in Heredia.

Etymology.—*Belthea oni* is named after the father of the first author, On Kawara, a modern conceptual artist who frequently “dances” around the globe. (The artist uses a shortened version of the first author’s last name.)

Host plants.—Unknown.

Remarks.—*Belthea oni* closely resembles *B. phosphoropa*, *B. picolella*, and some species of *Commatica* Meyrick. The number of forewing radial veins has been misinterpreted as a difference between *Belthea* and *Commatica*. Clarke (1969) illustrated the venation of *Belthea* and depicted it

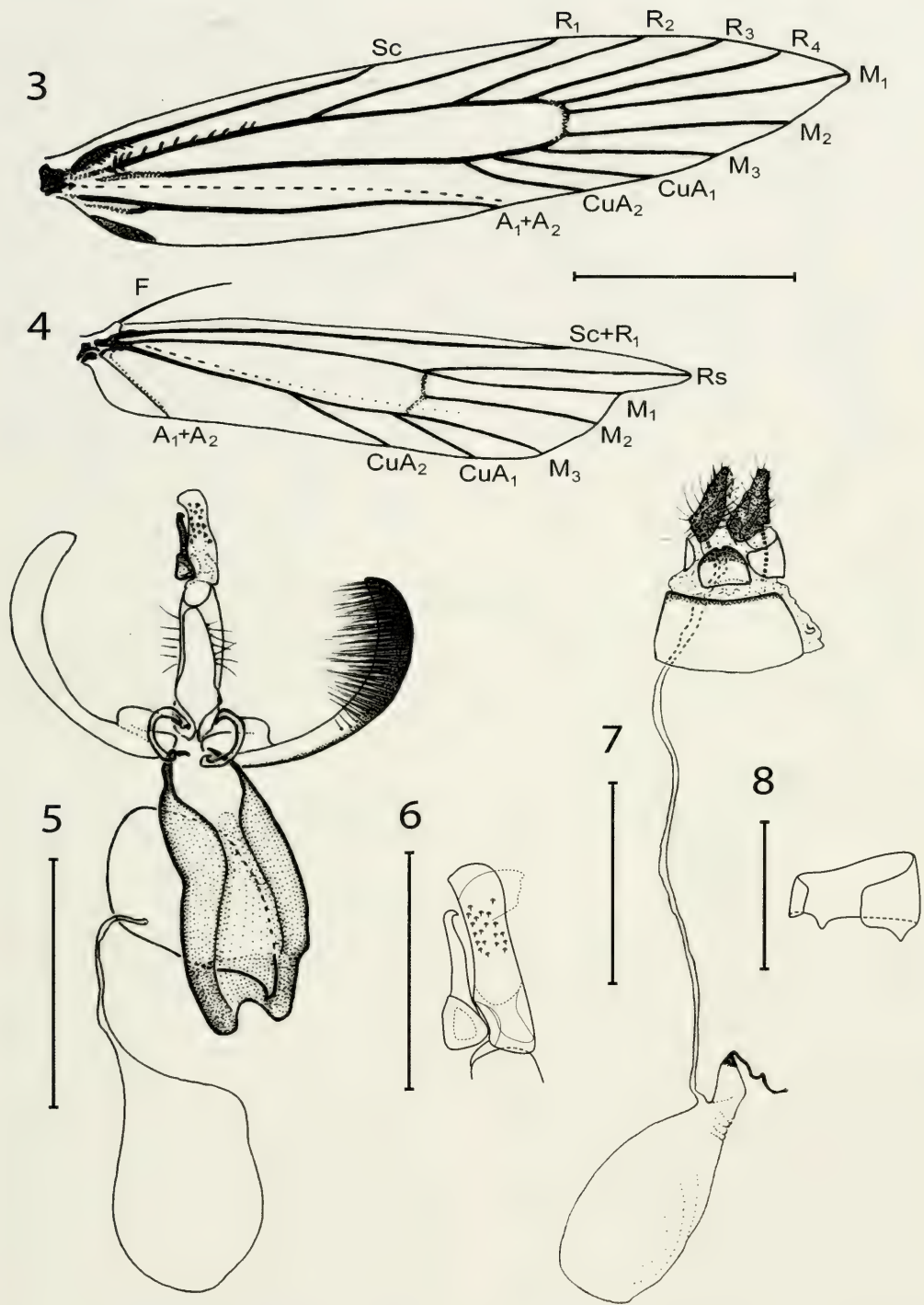
as differing from *Commatica* in having three forewing radial veins. After re-examining the wing venation of all species of *Belthea*, we conclude that *Belthea* and *Commatica eremna*, the type species of *Commatica*, all have four.

Although Busck (1914) included a description of wings and genitalia when he proposed *Belthea*, he made no reference to *Commatica* Meyrick. Unfortunately, Meyrick did not dissect or illustrate the genitalia of any of the species he described, and it is clear from illustrations in Clarke (1969) that the male genitalia of several species of *Commatica* (e.g., *C. acropelta* Meyrick, *C. metochra* Meyrick) closely resemble those of *Belthea phosphoropa*, whereas others differ considerably. We do not propose a generic synonymy or transfer any species for two reasons: 1) a cladistic analysis of species in *Belthea* and other closely related genera is beyond the scope of this project; and 2) types of most *Commatica* species could not be examined during the time available for this study. We tentatively place *oni* in *Belthea* because of its close similarity in male genitalia and wing shape to the lectotype of *Belthea phosphoropa*.

DANCING

Adults of both sexes of *Belthea oni* dance in circles on the adaxial surface of different kinds of leaves. The adult generally prefers a leaf that is fairly smooth and broad. Most observations were made of moths on a leaf of Rutaceae or Melastomataceae, but some adults were seen dancing on a leaf of an aroid, a fern, and a *Cecropia* sp. (Cecropiaceae). The adult usually prefers to dance on a leaf that is exposed to sunlight, rather than one that is hidden. Neither sex was observed walking or running in a straight line.

When dancing, the moth secures one of its forelegs as a pivot while shuffling the other legs laterally so that it can run rapidly in a circle. The moth does not favor a particular direction of rotation—in 24 independent observations, the moth made 1,228



Figs. 3–8. Wing venation and genitalia of *Belthecca oni*. 3, Forewing of male. 4, Hindwing of male. 5, Male genitalia, ventral view. 6, Male genitalia, enlargement of uncus and gnathos. 7, Female genitalia, ventral view. 8, Female genitalia, enlargement of eighth abdominal tergum. Scale bar = 1.0 mm in all figures except 6 and 8 where scale bar = 0.5 mm.

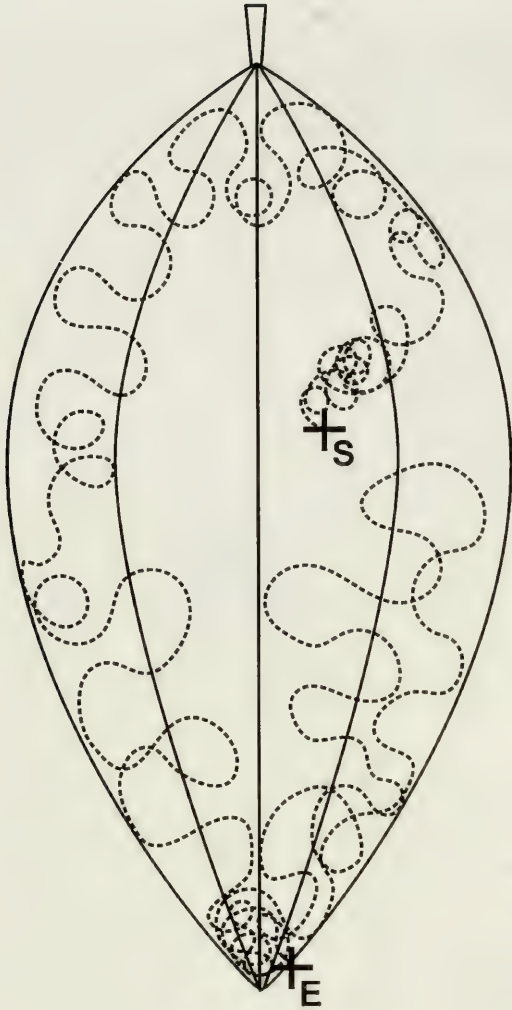


Fig. 9. A dancing path of *Belthecha oni*. S = start point, E = end point.

clockwise and 1,217 counterclockwise quarter-turns; rotating in a given direction was statistically insignificant ($\chi^2 = 0.049$, $df = 1$, $P > 0.2$). When the moth rotates clockwise, it anchors its right foreleg, and when it rotates counterclockwise, it anchors its left foreleg. The leg that is used as an anchor moves very little compared to the other legs, only shifting it slightly when the moth makes large circles, changes direction, or moves to another region of the leaf. In general, dancing takes place over the entire leaf, but at times can be localized to certain areas (Fig. 9). Each antenna is held

out laterally while the moth dances, and in one case, a moth was seen rotating slowly around a water droplet with its proboscis extended to the droplet (Fig. 10). When disturbed, the moth either stops dancing or flies from the leaf. The average time spent dancing was 71.14 seconds ($SD = 36.7$, $n = 24$) and dancing speed varied.

The behavioral significance of dancing in *Belthecha oni* and other microlepidoptera largely remains unknown. The adult of some *Brenthia* sp. (Choreutidae) move in a jerky fashion after alighting (Fletcher 1920, Forbes 1923, Rota 2003, Aiello and Becker 2004), and the display behavior may mimic the movement of salticid jumping spiders (Robinson et al. 1994, Rota 2003, Aiello and Becker 2004). Dancing in Gelechiidae, Momphidae, Cosmopterigidae, and Tineidae is quite different, as the moth typically rotates rapidly without jerky movements.

Observations of *B. oni* suggest that the adult dances during courtship. Typically only one moth was seen on a leaf, but there were three instances where two moths were dancing on the same leaf, two of which involved a male and a female. In one case, as soon as one of the sexes began dancing, the other danced also, and several seconds after one stopped, the other also stopped. This "dance-stop" scenario was repeated four times, and in each instance, dancing lasted 4–5 seconds before one of the moths stopped. Morrison (1968) described a similar scenario in *Dryadula pactoila* Meyrick (Tineidae). He observed a male in captivity running around in circles beside a female while fanning his wings, and repeatedly dancing and stopping until the pair mated. Unfortunately we were able to witness dance-stop behavior between only two individuals, and the pair flew away before the outcome of the scenario could be observed. Additional observations are necessary to conclusively determine that this dance-stop behavior is associated with courtship in microlepidoptera.

The moth also may dance to confuse a predator that uses visual cues for hunting.

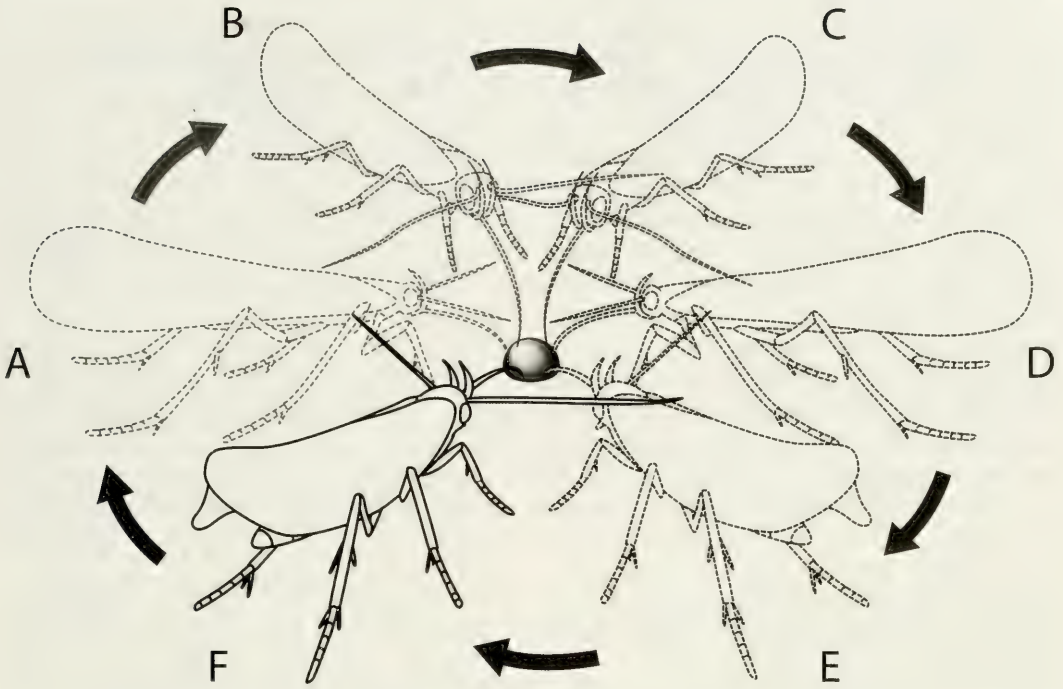


Fig. 10. Illustration showing how *Belthea oni* dances while drinking from a drop of water. The moth shuffles its legs and rotates from point A to point F and back to point A to make one dancing rotation. Rotation can be clockwise or counterclockwise.

At El Ceibo, similar dancing behaviors were observed in distantly related arthropods that have very different methods of courtship, suggesting that factors other than courtship may have selected independently for dancing in different lineages. A dancing pattern nearly identical to that of *Belthea oni* was observed in a black psycodid fly and several Collembola on the surface of leaves from which *B. oni* were collected. Similarly, Robinson (1988:73) reported that, "In Sulawesi, [a] momphid and its dance are the model for, or mimic an identical display by a similarly coloured collembolan—*Lepidocyrtus* sp. (Entomobryidae)." We believe that microlepidoptera dance for courtship, but it may also be that moths and distantly related arthropods dance to avoid capture by confusing predators such as salticid spiders that use visual cues to adjust for jumping distance. Future studies on dancing demand rigorous hypothesis-based behavioral experiments that

test the ecological and evolutionary significance of dancing in moths and other arthropods.

ACKNOWLEDGMENTS

We thank Klaus Sattler (formerly Department of Entomology, The Natural History Museum, London, UK) for discussion on *Belthea*. John Brown (Systematic Entomology Laboratory [SEL], USDA, Washington D.C., USA) and Ronald Hodges (formerly SEL, USDA, Washington D.C., USA) gave critical comments on an earlier version of the manuscript which greatly improved its quality. Christian Thompson (SEL, USDA, Washington D.C., USA) provided nomenclatural suggestions on the specific epithet. Donald Davis (Department of Entomology, USNM, Washington D.C., USA), Keitaro Eda (Shizuoka, Japan), Jerry Powell (Essig Museum of Natural History, Berkeley, CA, USA), Gaden Robinson (Department of Entomology, The Natural His-

tory Museum, London, UK), and Jadranka Rota (University of Connecticut, Storrs, CT, USA), provided information on dancing behavior. We also thank Robert Denno, Stephanie Johnson, Silvana-Marten Rodriguez, Jeffrey Sosa-Calvo, and Gina Wimp (University of Maryland, College Park, MD, USA) who gave comments on the manuscript, and discussed the potential evolutionary and ecological significance of dancing. The first author thanks David Wagner (University of Connecticut, Storrs, CT, USA) for introducing him to the microlepidoptera of Costa Rica in 2002. This study was made possible by funding provided to the first author through the Arthropods of La Selva (ALAS) ATBI research expeditions (2002–2004), The University of Maryland Graduate School, and the Organization for Tropical Studies (OTS) 04-01 Tropical Ecology graduate course.

LITERATURE CITED

- Aiello, A. and V. O. Becker. 2004. Display of the "Peacock Moth": *Brenthia* spp. (Choreutidae: Brenthiinae). *Journal of the Lepidopterists' Society* 58: 55–58.
- Busck, A. 1914. New genera and species of microlepidoptera from Panama. *Proceedings of the United States National Museum* 47: 1–67.
- Clarke, J. F. G. 1969. Catalogue of the type specimens of microlepidoptera in the British Museum (Natural History) described by Edward Meyrick. Vol. 6. Glyphipterigidae, Gelechiidae (A–C). Trustees of the British Museum (Natural History), London, 537 pp.
- Clemens, B. 1860. Contributions to American Lepidopterology, No. 4. *Proceedings of the Academy of Natural Sciences of Philadelphia* [12]: 156–174.
- Comstock, J. H. 1918. The wings of insects: an exposition of the uniform terminology of the wing-veins of insects and a discussion of the more general characteristics of the wings of the several orders of insects. Comstock, Ithaca, 430 pp.
- Fletcher, T. B. 1920. Life-histories of Indian Insects—Microlepidoptera. *Memoirs of the Department of Agriculture of India, Entomological Series* 6: 1–217.
- Forbes, W. T. M. 1923. The Lepidoptera of New York and neighboring states. Cornell University Agricultural Experiment Station, Memoir 68, 729 pp.
- Klots, A.B. 1970. Lepidoptera, pp. 115–130. *In* Tuxen, S. L. ed. *Taxonomist's Glossary of Genitalia in Insects*. Munksgaard, Copenhagen, 359 pp.
- Meyrick, E. 1922. Descriptions of South American Micro-Lepidoptera. *Transactions of the Entomological Society of London* 1922: 65–116.
- Morrison, B. 1968. A further record of *Dryadula pactoria* Meyrick (Lep., Tineidae) in Britain with notes on its life history. *Entomologist's Gazette* 19: 181–188.
- Plant, C. W. 1980. Unusual behavior of *Mompha nodicolella* Fuchs (Lep.: Momphidae). *The Entomologist's Record and Journal of Variation* 92: 255–256.
- Robinson, G. 1988. The systematic position of *Thermocrates epischista* Meyrick (Lepidoptera: Tineidae) and the biology of the Dryadulinae. *Nota Lepidopterologica* 11: 70–79.
- Robinson, G. S., K. R. Tuck, and M. Schaffer. 1994. A Field Guide to the Smaller Moths of South-East Asia. Malaysian Nature Society, Kuala Lumpur, 309 pp.
- Rota, J. 2003. Choreutidae (Lepidoptera) of La Selva Biological Station (Costa Rica): taxonomy, ultrastructure of immature states, and life history. Master's Thesis, University of Connecticut, Storrs, 160 pp.